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Calculating linkage intensities by product method[1]

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Abstract : General formulae for testing the expected phenotypic ratios and for detecting the linkage are given. Tables for obtaining crossing over values by the product method for different mating types and different phenotypic ratios are appended. Standard error can also be found along with the estimate. An example is given to illustrate the use of the appended tables.

Product method has been suggested to estimate the linkage intensity between two factors from F_2 or backcross of double heterozygotes (Fisher and Balmukand, 1928 ; Immer, 1930 ; Bailey, 1961 and Fisher, 1970). The product method is easy to use and the calculation of crossing over value can be greatly facilitated when suitable tables are available, it is affected the least by differential mortality of gamates or zygotes (Immer, 1930), it has in large samples a variance as small as possible (Fisher, 1970 and Liu, 1981), and it is easy to tabulate.

Let the four phenotypic classes of the progeny be denoted by AB, Ab, aB and ab and designating their observed frequencies by a, b, c and d respectively . Further, let expected phenotypic ratios of A : a and B : b be $\lambda_1 : \lambda_2$ and $\mu_1 : \mu_2$ respectively. Test of expected phenotypic ratios and the detection of linkage may be performed by using the three χ^2's listed in the following table, χ^2_A and χ^2_B are ratio χ^2's and χ^2_L linkage χ^2, all with one degree of freedom.

	Phenotype				
	AB	Ab	aB	ab	Total
Observed nos.	a	b	c	d	n
Expected nos.	$\lambda_1 u_1 D$	$\lambda_1 u_2 D$	$\lambda_2 u_1 D$	$\lambda_2 u_2 D$	n

A : $a=\lambda_1 : \lambda_2$, B : $b=u_1 : u_2$ and $D=n/(\lambda_1+\lambda_2)(u_1+u_2)$

(1) $\chi^2_A=[\lambda_2(a+b)-\lambda_1(c+d)]^2/[(\lambda_1\lambda_2^2u_1+\lambda_1\lambda_2^2u_2+\lambda_1^2\lambda_2u_1+\lambda_1^2\lambda_2u_2)D]$

(2) $\chi^2_B=[u_2(a+c)-u_1(b+d)]^2/[(\lambda_1u_1u_2^2+\lambda_1u_1^2u_2+\lambda_2u_1u_2^2+\lambda_2u_1^2u_2)D]$

(3) $\chi^2_L=[u_2(\lambda_2a-\lambda_1c)-u_1(\lambda_2b-\lambda_1d)]^2/[\lambda_1\lambda_2u_1u_2(\lambda_1u_1+\lambda_1u_2+\lambda_2u_1+\lambda_2u_2)D]$

It is easy to see that the ratio of the product ad(or bc)to the product bc (or ad) is a function of p, i. e., crossing over value. By subsituting the theoretical frequencies of a, b, c and

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d into the ratio, we have an equation in the form ad/bc (or bc/ad)=func. (p), a quadratic equation of which p is taken to be the positive solution. The product equations for different mating types and different phenotypic ratios are given by Liu (1981). In calculating linkage intensities by this method, the observed frequencies for the four classes, a, b, c and d are substituted in the equation and the crossing over value determined. Formulae for the sampling variances of crossing over values calculated by the product method may be developed from the general equation given by Fisher (1970) and the explicit formulae for variances can be found in Liu (1981).

In estimating linkage intensities from the equations given by Liu (1981), it is necessary to solve a quadratic equation. Although this causes no difficulty, it may be rather laborious under some conditions and will always be time consuming. It is a great advantage of the product method that it permits itself readily to the calculation of tables from which crossing over values and their standard errors may be determined with the entering of the observed ratio of product ad/bc (for repulsion) or bc/ad (for coupling).

Tables for calculating linkage intensities by the product method for two 3 : 1 ratios have been given by Fisher and Balmukand (1928) and more extended tables have been presented by Immer (1930). Tables appended in this paper include some even more complex ratios than those of Immer's and substitute the probable error used in Immer's tables by the standard error which is far more useful in making statistical inferences.

By referring to the appended tables (Table 1 to Table 21), the labor of culculating linkage intensities can be materially reduced. Crossing over value can be determined by a given value of the ratio of products ad/bc or bc/ad for different mating types and different phenotypic ratios. In these tables, the ratio of products for repulsion is given as ad/bc and for coupling bc/ad. This is done because it is more convenient to keep the ratios less than one for all crossing over values less than 0.5.

By the aid of the appended tables, the estimation of crossing over values by the product method then simply involves only the calculation of ad/bc or bc/ad from the four observed phenotypic classes. If the value of ad/bc or bc/ad is not on the tables, interpolation may be employed to find the linkage intensity. The standard error of the estimate is obtained by dividing the tabulated standard error by the square root of the total frequency, i. e., $\sqrt{n}$.

As an example of the use of the product method, the following data taken from an experiment carried out by M. H. Lin at the Taiwan Agricultural Research Institute in 1980 is used. A ligureless (lg) and narrow leaf (nal) mutant rice (H106) was crossed with a ligured (Lg) and broad leaf (Nal) normal one (Tainan No. 5). The F_2 may be classified as under :

LgNal (a)	Lgnal (b)	lgNal (c)	lgnal (d)	Total (n)
3511	172	188	1009	4880

Three single degree of freedom χ^2's for testing the expected phenotypic ratios and for detecting the linkage are as follows :

$\chi^2_{Lg}=0.578$, Pr $(\chi_1^2>0.578)=0.54662$

$\chi^2_{Nal}=1.662$, Pr $(\chi_1^2>1.662)=0.19411$

$\chi^2_L = 3017.444$, Pr $(\chi^2_1 > 3017.444) = 0$

Two ratio χ^2's show that the expected 3 : 1 and 3 : 1 ratios are satisfactory realized, but the linkage χ^2 indicate that there is strong evidence for linkage. Since the cross is one of coupling, we calculate bc/ad=0.00913. By interpolation in Table 1 we found the crossing over value to be 0.07741. From the same table we also find by interpolation that the standard error is 0.2301 which, divided by $\sqrt{4880}$, gives a standard error of the above estimate of crossing over value of 0.00401.

If complementary, duplicate or inhibiting factors had been involved in determining one or both of the character pairs from a cross, we would have estimated the linkage intensity by using the appropriate table depending on the expected phenotypic ratios.

It is noted that the probabilities of the four phenotypes (AB, Ab, aB and ab) from a tissue culture of F_1 anther are identical to those from a backcross of F_1 to either parent. Therefore, the anther culture data may be analyzed as though they were the backcross data for linkage estimation, regardless of whether the materials are haploids, polyploids through chromosome multiplying or the pooled one.

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連鎖強度之乘積法估算[1]

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中 文 摘 要

本文導出測驗外表型分別比及測驗遺傳連鎖是否存在之一般化公式。若遺傳連鎖顯著存在，則視各種不同交配類型及各種不同分離比，連鎖强度之乘積法估值可經由本文中之附表直接查出，附表中並列有各估值之標準偏差。文末附有一例以說明本文附表的使用法。

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Table 1. Crossing over value (COV) and their standard errors based on the product method when both character pair are determined by a single factor difference-3 : 1and 3 : 1 for F_2 or1 : 1 and 1 : 1 for backcross (BC)

COV %	Ratio of products, %				$\sqrt{n} \times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	0.020	0.010	0.014	0.010	99.988	9.950	10.008	9.950
2	0.080	0.042	0.055	0.042	99.950	14.000	14.166	14.000
3	0.180	0.096	0.126	0.096	99.888	17.059	17.365	17.059
4	0.321	0.174	0.228	0.174	99.800	19.596	20.070	19.596
5	0.503	0.277	0.363	0.277	99.688	21.794	22.460	21.794
6	0.727	0.407	0.532	0.407	99.552	23.749	24.627	23.749
7	0.992	0.567	0.737	0.567	99.391	25.515	26.626	25.515
8	1.301	0.756	0.979	0.756	99.206	27.129	28.492	27.129
9	1.653	0.978	1.262	0.978	98.997	28.618	30.251	28.618
10	2.051	1.235	1.586	1.235	98.764	30.000	31.920	30.000
11	2.495	1.528	1.954	1.528	98.509	31.289	33.513	31.289
12	2.986	1.860	2.369	1.860	98.230	32.496	35.041	32.496
11	3.527	2.233	2.832	2.233	97.928	33.630	36.511	33.630
13	4.118	2.650	3.347	2.650	97.604	34.699	37.931	34.699
15	4.763	3.114	3.915	3.114	97.259	35.707	39.306	35.707
16	5.462	3.628	4.540	3.628	96.892	36.661	40.641	36.661
17	6.218	4.195	5.225	4.195	96.504	37.563	41.941	37.563
18	7.033	4.819	5.973	4.819	96.096	38.419	43.207	38.419
19	7.911	5.502	6.787	5.502	95.667	39.230	44.444	39.230
20	8.854	6.250	7.670	6.250	95.219	40.000	45.653	40.000
21	9.865	7.066	8.628	7.066	94.752	40.731	46.838	40.731
22	10.948	7.955	9.663	7.955	94.266	41.425	47.999	41.425
23	12.107	8.922	10.780	8.922	93.762	42.083	49.139	42.083
24	13.345	9.972	11.984	9.972	93.241	42.708	50.259	42.708
25	14.667	11.111	13.279	11.111	92.702	43.301	51.360	43.301
26	16.077	12.345	14.671	12.345	92.147	43.863	52.444	43.863
27	17.581	13.680	16.164	13.680	91.576	44.396	53.512	44.396
28	19.185	15.123	17.766	15.123	90.990	44.900	54.565	44.900
29	20.894	16.683	19.481	16.683	90.388	45.376	55.604	45.376
30	22.715	18.367	21.318	18.367	89.771	45.826	56.629	45.826
31	24.654	20.185	23.283	20.185	89.141	46.249	57.641	46.249
32	26.721	22.145	25.383	22.145	88.497	46.648	58.641	46.648
33	28.922	24.259	27.627	24.259	87.839	47.021	59.629	47.021
34	31.268	26.538	30.025	26.538	87.169	47.371	60.607	47.371
35	33.767	28.994	32.585	28.994	86.486	47.697	61.574	47.697
36	36.431	31.641	35.317	31.641	85.792	48.000	62.530	48.000
37	39.270	34.492	38.234	34.492	85.086	48.280	63.477	48.280
38	42.299	37.565	41.346	37.565	84.369	48.539	64.415	48.539
39	45.530	40.876	44.667	40.876	83.640	48.775	65.343	48.775
40	48.980	44.444	48.211	44.444	82.902	48.990	66.262	48.990
41	52.663	48.291	51.993	48.291	82.153	49.183	67.173	49.183
42	56.598	52.438	56.029	52.438	81.395	49.356	68.075	49.356
43	60.806	56.910	60.337	56.910	80.626	49.508	68.969	49.508
44	65.307	61.735	64.937	61.735	79.849	49.639	69.855	49.639
45	70.126	66.942	69.850	66.942	79.062	49.749	70.733	49.749
46	75.289	72.565	75.098	72.565	78.267	49.840	71.602	49.840
47	80.824	78.640	80.709	78.640	77.463	49.910	72.464	49.910
48	86.763	85.207	86.708	85.207	76.650	49.960	73.317	49.960
49	93.142	92.311	93.128	92.311	75.829	49.990	74.163	49.990
50	100.000	100.000	100.000	100.000	75.000	50.000	75.000	50.000

Table 2. Crossing over value (COV) and their standard errors based on the product method when one character pair is determined by a single factor difference and the other character pair by two complementary factor differences-3 : 1 and 9 : 7 for F_2 or 1 : 1 and 1 : 3 for backcross (BC)

COV %	Ratio of products, %				$\sqrt{n} \times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	33.350	0.513	0.519	0.513	5,164.391	19.754	16.124	19.754
2	33.400	1.051	1.075	1.051	2,582.814	27.601	22.540	27.601
3	33.484	1.617	1.670	1.617	1,722.563	33.406	27.318	33.406
4	33.601	2.211	2.306	2.211	1,292.641	38.129	31.243	38.129
5	33.752	2.834	2.983	2.834	1,034.849	42.147	34.627	42.147
6	33.937	3.488	3.703	3.488	863.121	45.656	37.632	45.656
7	34.157	4.173	4.467	4.173	740.570	48.775	40.354	48.775
8	34.412	4.891	5.277	4.891	648.753	51.582	42.858	51.582
9	34.702	5.644	6.133	5.644	577.424	54.131	45.188	54.131
10	35.029	6.433	7.038	6.433	520.434	56.464	47.376	56.464
11	35.392	7.259	7.992	7.259	473.871	58.610	49.447	58.610
12	35.793	8.124	8.997	8.124	435.126	60.594	51.421	60.594
13	36.233	9.029	10.054	9.029	402.393	62.435	53.312	62.435
14	36.711	9.977	11.166	9.977	374.382	64.148	55.134	64.148
15	37.231	10.970	12.333	10.970	350.146	65.748	56.896	65.748
16	37.792	12.008	13.557	12.008	328.977	67.244	58.607	67.244
17	38.395	13.095	14.839	13.095	310.331	68.647	60.275	68.647
18	39.043	14.232	16.182	14.232	293.785	69.963	61.906	69.963
19	39.736	15.422	17.586	15.422	279.007	71.199	63.505	71.199
20	40.476	16.667	19.054	16.667	265.729	72.363	65.077	72.363
21	41.265	17.969	20.586	17.969	253.736	73.458	66.627	73.458
22	42.105	19.332	22.185	19.332	242.850	74.489	68.159	74.489
23	42.997	20.757	23.852	20.757	232.926	75.461	69.675	75.461
24	43.943	22.249	25.588	22.249	223.841	76.377	71.179	76.377
25	44.946	23.810	27.396	23.810	215.494	77.239	72.675	77.239
26	46.009	25.443	29.278	25.443	207.798	78.052	74.165	78.052
27	47.133	27.152	31.233	27.152	200.679	78.817	75.652	78.817
28	48.321	28.941	33.265	28.941	194.073	79.537	77.138	79.537
29	49.578	30.813	35.375	30.813	187.926	80.214	78.626	80.214
30	50.904	32.773	37.564	32.773	182.191	80.849	80.118	80.849
31	52.305	34.825	39.834	34.825	176.827	81.445	81.616	81.445
32	53.783	36.975	42.187	36.975	171.797	82.003	83.123	82.003
33	55.343	39.226	44.623	39.226	167.070	82.524	84.641	82.524
34	56.989	41.585	47.145	41.585	162.618	83.010	86.172	83.010
35	58.725	44.056	49.754	44.056	158.416	83.461	87.719	83.461
36	60.557	46.646	52.452	46.646	154.442	83.879	89.283	83.879
37	62.489	49.362	55.238	49.362	150.676	84.264	90.868	84.264
38	64.526	52.210	58.115	52.210	147.100	84.618	92.475	84.618
39	66.676	55.198	61.084	55.198	143.699	84.941	94.108	84.941
40	68.944	58.333	64.146	58.333	140.459	85.234	95.768	85.234
41	71.338	61.625	67.302	61.625	137.367	85.497	97.458	85.497
42	73.865	65.081	70.551	65.081	134.410	85.732	99.182	85.732
43	76.532	68.712	73.897	68.712	131.580	85.937	100.942	85.937
44	79.350	72.527	77.337	72.527	128.865	86.115	102.741	86.115
45	82.328	76.540	80.874	76.540	126.257	86.264	104.583	86.264
46	85.475	80.760	84.508	80.760	123.748	86.386	106.472	86.386
47	88.803	85.202	88.237	85.202	121.331	86.481	108.410	86.481
48	92.324	89.879	92.063	89.879	118.998	86.549	110.401	86.549
49	96.052	94.806	95.984	94.806	116.745	86.589	112.452	86.589
50	100.000	100.000	100.000	100.000	114.564	86.603	114.564	86.603

Table 3. Crossing over value (COV) and their standard errors based on the product method when one character pair is determined by a single factor difference and the other character pair by two duplicate factor differences-3 : 1 and 15 : 1 for F_2 or 1:1 and 3:1 for backcross (BC)

COV %	Ratio of products, %				$\sqrt{n} \times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	0.028	0.513	0.512	0.513	199.987	19.754	28.100	19.754
2	0.110	1.051	1.048	1.051	199.946	27.601	39.491	27.601
3	0.248	1.617	1.609	1.617	199.879	33.406	48.075	33.406
4	0.441	2.211	2.197	2.211	199.786	38.129	55.191	38.129
5	0.690	2.834	2.811	2.834	199.665	42.147	61.361	42.147
6	0.995	3.488	3.455	3.488	199.518	45.656	66.857	45.656
7	1.356	4.173	4.127	4.173	199.344	48.775	71.839	48.775
8	1.775	4.891	4.831	4.891	199.143	51.582	76.415	51.582
9	2.252	5.644	5.567	5.644	198.916	54.131	80.658	54.131
10	2.787	6.433	6.336	6.433	198.662	56.464	84.624	56.464
11	3.382	7.259	7.140	7.259	198.382	58.610	88.353	58.610
12	4.038	8.124	7.981	8.124	198.075	60.594	91.878	60.594
13	4.755	9.029	8.860	9.029	197.742	62.435	95.224	62.435
14	5.535	9.977	9.778	9.977	197.383	64.148	98.412	64.148
15	6.379	10.970	10.739	10.970	196.997	65.748	101.460	65.748
16	7.288	12.008	11.743	12.008	196.586	67.244	104.382	67.244
17	8.265	13.095	12.792	13.095	196.148	68.647	107.190	68.647
18	9.311	14.232	13.890	14.232	195.685	69.963	109.894	69.963
19	10.427	15.422	15.037	15.422	195.196	71.199	112.503	71.199
20	11.616	16.667	16.237	16.667	194.681	72.363	115.025	72.363
21	12.880	17.969	17.492	17.969	194.140	73.458	117.468	73.458
22	14.221	19.332	18.806	19.332	193.574	74.489	119.835	74.489
23	15.641	20.757	20.180	20.757	192.983	75.461	122.134	75.461
24	17.143	22.249	21.618	22.249	192.366	76.377	124.368	76.377
25	18.730	23 810	23.123	23.810	191.725	77.239	126.542	77.239
26	20.405	25.443	24.700	25.443	191.058	78.052	128.659	78.052
27	22.171	27.152	26.351	27.152	190.366	78.817	130.722	78.817
28	24.032	28.941	28.081	28.941	189.649	79.537	132.735	79.537
29	25.991	30.813	29.894	30.813	188.908	80.214	134.701	80.214
30	28.051	32.773	31.795	32.773	188.141	80.849	136.620	80.849
31	30.219	34.825	33.789	34.825	187.351	81.445	138.497	81.445
32	32.497	36.975	35.882	36.975	186.535	82.003	140.332	82.003
33	34.890	39.226	38.079	39.226	185.695	82.524	142.128	82.524
34	37.404	41.585	40.386	41.585	184.831	83.010	143.885	83.010
35	40.044	44.056	42.810	44.056	183.943	83.461	145.606	83.461
36	42.816	46.646	45.359	46.646	183.030	83.879	147.292	83.879
37	45.727	49.362	48.039	49.362	182.093	84.264	148.944	84.264
38	48.782	52.210	50.861	52.210	181.132	84.618	150.563	84.618
39	51.990	55.198	53.833	55.198	180.147	84.941	152.150	84.941
40	55.357	58.333	56.964	58.333	179.138	85.234	153.706	85.234
41	58.893	61.625	60.266	61.625	178.104	85.497	155.231	85.497
42	62.605	65.081	63.750	65.081	177.047	85.732	156.728	85.732
43	66.505	68.712	67.430	68.712	175.965	85.937	158.195	85.937
44	70.601	72.527	71.319	72.527	174.859	86.115	159.634	86.115
45	74.905	76.540	75.431	76.540	173.728	86.264	161.046	86.264
46	79.249	80.760	79.785	80.760	172.573	86.386	162.431	86.386
47	84.186	85.202	84.398	85.202	171.393	86.481	163.788	86.481
48	89.190	89.879	89.290	89.879	170.189	86.549	165.120	86.549
49	94.456	94.806	94.482	94.806	168.960	86.589	166.425	86.589
50	100.000	100.000	100.000	100.00	167.705	86.603	167.705	86.603

Table 4. Crossing over value (COV) and their standard errors based on the product method when one character pair is determined by a single factor difference and the other character pair by two inhibiting factor differences-3 : 1 and 3 : 13 for F_2 or 1 : 1 and 1 : 3 for backcross (BC)

COV %	Ratio of products, %				$\sqrt{n} \times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	60.012	0.513	1.513	0.513	14,383.65	19.754	28.303	19.754
2	60.046	1.051	3.053	1.051	7,191.466	27.601	40.060	27.601
3	60.105	1.617	4.620	1.617	4,793.908	33.406	49.113	33.406
4	60.186	2.211	6.212	2.211	3,595.007	38.129	56.780	38.129
5	60.291	2.834	7.831	2.834	2,875.568	42.147	63.571	42.147
6	60.419	3.488	9.476	3.488	2,395.860	45.656	69.750	45.656
7	60.572	4.173	11.146	4.173	2,053.140	48.775	75.473	48.775
8	60.748	4.891	12.842	4.891	1,796.037	51.582	80.843	51.582
9	60.948	5.644	14.563	5.644	1,596.011	54.131	85.933	54.131
10	61.173	6.433	16.309	6.433	1,435.939	56.464	90.795	56.464
11	61.423	7.259	18.080	7.259	1,304.922	58.610	95.470	58.610
12	61.698	8.124	19.875	8.124	1,195.697	60.594	99.989	60.594
13	61.999	9.029	21.695	9.029	1,103.234	62.435	104.379	62.435
14	62.325	9.977	23.537	9.977	1,023.939	64.148	108.659	64.148
15	62.678	10.970	25.403	10.970	955.179	65.748	112.849	65.748
16	63.058	12.008	27.292	12.008	894.978	67.244	116.964	67.244
17	63.466	13.095	29.203	13.095	841.823	68.647	121.016	68.647
18	63.901	14.232	31.136	14.232	794.541	69.963	125.017	69.963
19	64.366	15.422	33.090	15.422	752.202	71.199	128.978	71.199
20	64.859	16.667	35.065	16.667	714.065	72.363	132.909	72.363
21	65.383	17.969	37.060	17.969	679.528	73.458	136.817	73.458
22	65.939	19.332	39.074	19.332	648.099	74.489	140.710	74.489
23	66.525	20.757	41.108	20.757	619.373	75.461	144.597	75.461
24	97.145	22.249	43.160	22.249	593.010	76.377	148.484	76.377
25	67.799	23.810	45.229	23.810	568.726	77.239	152.378	77.239
26	68.487	25.443	47.315	25.443	546.279	78.052	156.285	78.052
27	69.211	27.152	49.417	27.152	525.466	78.817	160.211	78.817
28	69.973	28.941	51.535	28.941	506.109	79.537	164.162	79.537
29	70.773	30.813	53.666	30.813	488.058	80.214	168.145	80.214
30	71.613	32.773	55.812	32.773	471.180	80.849	172.165	80.849
31	72.494	34.825	57.970	34.825	455.362	81.445	176.227	81.445
32	73.418	36.975	60.140	36.975	440.502	82.003	180.339	82.003
33	74.386	39.226	62.321	39.226	426.513	82.524	184.505	82.524
34	75.401	41.585	64.511	41.585	413.316	83.010	188.732	83.010
35	76.464	44.056	66.711	44.056	400.843	83.461	193.026	83.461
36	77.577	46.646	68.918	46.646	389.032	83.879	197.392	83.879
37	78.743	49.362	71.133	49.362	377.829	84.264	201.839	84.264
38	79.963	52.210	73.352	52.210	367.184	84.618	206.372	84.618
39	81.241	55.198	75.577	55.198	357.053	84.941	210.998	84.941
40	82.578	58.333	77.805	58.333	347.396	85.234	215.725	85.234
41	83.979	61.625	80.035	61.625	338.178	85.497	220.559	85.497
42	85.445	65.081	82.266	65.081	329.366	85.732	225.510	85.732
43	86.980	68.712	84.497	68.712	320.930	85.937	230.586	85.937
44	88.589	72.527	86.726	72.527	312.844	86.115	235.794	86.115
45	90.273	76.540	88.953	76.540	305.082	86.264	241.146	86.264
46	92.039	80.760	91.176	80.760	297.623	86.386	246.650	86.386
47	93.889	85.202	93.393	85.202	290.445	86.481	252.317	86.481
48	95.828	89.879	95.604	89.879	283.529	86.549	258.159	86.549
49	97.864	94.806	97.807	94.806	276.858	86.589	264.188	86.589
50	100.000	100.000	100.000	100.000	270.416	86.603	270.416	86.603

Table 5. Crossing over value (COV) and their standard errors based on the product method when one character pair is determined by a single factor difference and the other character pair by three complementary factor differences-3 : 1 and 27 : 37 for F_2 or 1 : 1 and 1 : 7 for backcross (BC)

COV	Ratio of products, %				$\sqrt{n} \times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
%	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	46.681	0.762	0.894	0.762	5790.434	28.062	18.753	28.062
2	46.724	1.549	1.826	1.549	3795.367	39.374	26.386	39.374
3	46.796	2.360	2.797	2.360	2530.410	47.846	32.167	47.846
4	46.898	3.199	3.808	3.199	1897.981	54.817	36.987	54.817
5	47.028	4.064	4.860	4.064	1518.562	60.811	41.195	60.811
6	47.188	4.957	5.952	4.957	1265.647	66.098	44.972	66.098
7	47.377	5.880	7.086	5.880	1085.020	70.841	48.427	70.841
8	47.597	6.832	8.263	6.832	949.572	75.147	51.630	75.174
9	47.847	7.816	9.482	7.816	844.243	79.090	54.632	79.090
10	48.127	8.832	10.746	8.832	759.995	82.725	57.470	82.725
11	48.439	9.881	12.053	9.881	691.079	86.094	60.173	86.094
12	48.783	10.965	13.406	10.965	633.662	89.229	62.761	89.229
13	49.159	12.085	14.804	12.085	585.088	92.157	65.254	92.157
14	49.569	13.243	16.247	13.243	543.462	94.899	67.666	94.899
15	50.012	14.439	17.738	14.439	507.393	97.472	70.008	97.472
16	50.490	15.675	19.275	15.675	475.839	99.892	72.292	99.892
17	51.003	16.952	20.860	16.952	448.003	102.170	74.526	102.170
18	51.553	18.274	22.493	18.274	423.263	104.319	76.719	104.319
19	52.141	19.640	24.175	19.640	401.130	106.346	78.876	106.346
20	52.767	21.053	25.905	21.053	381.212	108.261	81.006	108.261
21	53.432	22.514	27.684	22.514	363.192	110.070	83.112	110.070
22	54.139	24.027	29.512	24.027	346.810	111.781	85.200	111.781
23	54.887	25.592	31.391	25.592	331.852	113.397	87.275	113.397
24	55.680	27.212	33.318	27.212	318.138	114.925	89.341	114.925
25	56.518	28.889	35.296	28.889	305.520	116.369	91.403	116.369
26	57.403	30.626	37.324	30.626	293.868	117.732	93.464	117.732
27	58.337	32.425	39.402	32.425	283.076	119.019	95.528	119.019
28	59.321	34.289	41.530	34.289	273.050	120.233	97.598	120.233
29	60.358	36.221	43.708	36.221	263.711	121.377	99.678	121.377
30	61.450	38.224	45.936	38.224	254.988	122.453	101.772	122.453
31	62.599	40.301	48.214	40.301	246.821	123.464	103.883	123.464
32	63.808	42.455	50.541	42.455	239.157	124.412	106.013	124.412
33	65.079	44.691	52.916	44.691	231.950	125.299	108.168	125.299
34	66.416	47.011	55.341	47.011	225.158	126.126	110.349	126.126
35	67.820	49.420	57.813	49.420	218.745	126.897	112.560	126.897
36	69.296	51.923	60.332	51.923	212.678	127.611	114.806	127.611
37	70.848	54.524	62.899	54.524	206.929	128.271	117.088	128.271
38	72.478	57.227	65.511	57.227	201.471	128.877	119.412	128.877
39	74.190	60.038	68.168	60.038	196.282	129.431	121.780	129.431
40	75.990	62.963	70.869	62.963	191.340	129.934	124.198	129.934
41	77.882	66.007	73.612	66.007	186.626	130.386	126.668	130.386
42	79.870	69.177	76.398	69.177	182.123	130.789	129.195	130.789
43	81.961	72.480	79.224	72.480	177.815	131.142	131.784	131.142
44	84.159	75.923	82.089	75.923	173.688	131.448	134.439	131.448
45	86.472	79.513	84.991	79.513	169.729	131.705	137.166	131.705
46	88.905	83.260	87.929	83.260	165.926	131.915	139.969	131.915
47	91.466	87.172	90.900	87.172	162.269	132.078	142.855	132.078
48	94.163	91.259	93.904	91.259	158.746	132.195	145.829	132.195
49	97.005	95.531	96.938	95.531	155.349	132.264	148.898	132.264
50	100.000	100.000	100.000	100.000	152.069	132.288	152.069	132.288

Table 6. Crossing over value (COV) and their standard errors based on the product method when one character pair is determined by a single factor difference and the other character pair by three duplicate factor differences-3 : 1 and 63 : 1 for F_2 or 1 : 1 and 7 : 1 for backcross (BC)

COV	Ratio of products, %				$\sqrt{n} \times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
%	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	0.029	0.762	0.636	0.762	399.978	28.062	56.379	28.062
2	0.118	1.549	1.293	1.549	399.913	39.374	79.467	39.374
3	0.265	2.360	1.973	2.360	399.805	47.846	97.007	47.846
4	0.471	3.199	2.677	3.199	399.653	54.817	111.649	54.817
5	0.736	4.064	3.405	4.064	399.458	60.811	124.424	60.811
6	1.062	4.957	4.159	4.957	399.219	66.098	135.863	66.098
7	1.447	5.880	4.939	5.880	398.937	70.841	146.282	70.841
8	1.893	6.832	5.748	6.832	398.612	75.147	155.889	75.147
9	2.400	7.816	6.585	7.816	398.243	79.090	164.828	79.090
10	2.970	8.832	7.453	8.832	397.830	82.725	173.204	82.725
11	3.602	9.881	8.352	9.881	397.374	86.094	181.096	86.094
12	4.297	10.965	9.284	10.965	396.874	89.229	188.568	89.229
13	5.057	12.085	10.251	12.085	396.330	22.157	195.669	92.157
14	5.882	13.243	11.255	13.243	395.742	94.899	202.439	94.899
15	6.774	14.439	12.296	14.439	395.110	97.472	208.911	97.472
16	7.734	15.675	13.376	15.675	394.434	99.892	215.114	99.892
17	8.763	16.952	14.499	16.952	393.714	102.170	221.071	102.170
18	9.863	18.274	15.665	18.274	392.950	104.319	226.802	104.319
19	11.035	19.640	16.876	19.640	392.142	106.346	232.325	106.346
20	12.281	21.053	18.136	21.053	391.288	108.261	237.654	108.261
21	13.602	22.514	19.446	22.514	390.391	110.070	242.805	110.070
22	15.001	24.027	20.809	24.027	389.448	111.781	247.787	111.781
23	16.480	25.592	22.228	25.592	388.460	113.397	252.612	113.397
24	18.041	27.212	23.705	27.212	387.427	114.925	257.288	114.925
25	19.686	28.889	25.245	28.889	386.349	116.369	261.825	116.369
26	21.418	30.626	26.849	30.626	385.225	117.732	266.230	117.732
27	23.240	32.425	28.522	32.425	384.055	119.019	270.509	119.019
28	25.154	34.289	30.267	34.289	382.839	120.233	274.669	120.233
29	27.164	36.221	32.090	36.221	381.577	121.377	278.715	121.377
30	29.272	38.224	33.993	38.224	380.268	122.453	282.652	122.453
31	31.484	40.301	35.981	40.301	378.913	123.464	286.486	123.464
32	33.801	42.455	38.061	42.455	377.510	124.412	290.219	124.412
33	36.229	44.691	40.236	44.691	376.060	125.299	293.857	125.299
34	38.771	47.011	42.514	47.011	374.562	126.126	297.403	126.126
35	41.432	49.420	44.899	49.420	373.016	126.897	300.860	126.897
31	44.217	51.923	47.400	51.923	371.421	127.611	304.231	127.611
37	47.132	54.524	50.023	54.524	369.777	128.271	307.518	128.271
38	50.182	57.227	52.776	57.227	378.083	128.877	310.726	128.877
39	53.372	60.038	55.668	60.038	366.340	129.431	313.856	129.431
40	56.710	62.963	58.709	62.963	364.546	129.934	316.910	129.934
41	60.202	66.007	61.907	66.007	362.701	130.386	319.891	130.386
42	63.856	69.177	65.275	69.177	360.804	130.789	322.800	130.789
43	67.679	72.480	68.824	72.480	358.856	131.142	325.639	131.142
44	71.681	75.923	72.567	75.923	356.854	131.448	328.410	131.448
45	75.870	79.513	76.518	79.513	354.799	131.705	331.115	131.705
41	80.256	83.260	80.694	83.260	352.690	131.915	333.755	131.915
47	84.851	87.172	85.110	87.172	350.525	132.078	336.332	132.078
48	89.664	91.259	89.786	91.259	348.305	132.195	338.846	132.195
49	94.709	95.531	94.741	95.531	346.028	132.264	341.300	132.264
50	100.000	100.000	100.000	100.000	343.693	132.288	343.693	132.288

Table 7. Crossing over value (COV) and their standard errors based on the product method when both character pairs are determined by two complementary factor differences-9 : 7 and 9 : 7 for F_2 or 1 : 3 and 1 : 3 for backcross (BC)

COV	Ratio of products, %				$\sqrt{n} \times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
%	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	55.569	1.013	16.691	20.649	8606.730	28.109	80.852	158.344
2	55.609	2.051	17.624	21.318	4303.516	39.506	82.128	158.561
3	55.676	3.115	18.587	22.006	2869.177	48.087	83.411	158.763
4	55.769	4.207	19.582	22.715	2152.058	55.186	84.700	158.952
5	55.890	5.325	20.609	23.445	1721.826	61.325	85.999	159.126
6	56.037	6.473	21.668	24.197	1435.037	66.771	87.306	159.287
7	56.212	7.649	22.760	24.971	1230.215	71.686	88.623	159.433
8	56.415	8.854	23.884	25.769	1076.623	76.175	89.952	159.565
9	56.645	10.090	25.042	26.591	957.183	80.313	91.292	159.683
10	56.903	11.357	26.232	27.438	861.649	84.154	92.646	159.786
11	57.190	12.656	27.456	28.310	783.501	87.738	94.013	159.875
12	57.506	13.988	28.714	29.210	718.393	91.098	95.395	159.949
13	57.851	15.354	30.006	30.138	663.314	94.260	96.794	160.008
14	58.225	16.753	31.332	31.094	616.116	97.245	98.209	160.053
15	58.630	18.188	32.692	32.080	575.221	100.071	99.643	160.082
16	59.065	19.660	34.087	33.097	539.447	102.751	101.097	160.097
17	59.532	21.168	35.516	34.147	507.891	105.299	102.570	160.096
18	60.031	22.715	36.979	35.229	479.849	107.726	104.066	160.080
19	60.562	24.300	38.477	36.347	454.766	110.040	105.585	160.048
20	61.127	25.926	40.009	37.500	432.197	112.250	107.128	160.000
21	61.726	27.593	41.576	38.691	411.783	114.363	108.696	159.936
22	62.360	29.302	43.177	39.921	393.229	116.385	110.292	159.857
23	63.030	31.054	44.812	41.191	376.294	118.323	111.917	159.761
24	63.737	32.851	46.481	42.503	360.773	120.181	113.572	159.648
25	64.481	34.694	48.183	43.860	346.497	121.963	115.259	159.519
26	65.265	36.583	49.920	45.262	333.322	123.675	116.980	159.373
27	66.088	38.521	51.689	46.711	321.126	125.319	118.735	159.210
28	66.953	40.508	53.491	48.211	309.802	126.900	120.529	159.030
29	67.861	42.546	55.325	49.762	299.260	128.419	122.361	158.831
30	68.812	44.637	57.192	51.368	289.422	129.882	124.235	158.615
31	69.808	46.781	59.089	53.030	280.219	131.289	126.153	158.381
32	70.852	48.980	61.018	54.751	271.592	132.643	128.116	158.128
33	71.943	51.235	62.977	56.534	263.487	133.947	130.128	157.857
34	73.085	53.549	64.965	58.382	255.858	135.203	132.190	157.566
35	74.279	55.923	66.982	60.298	248.664	136.412	134.307	157.256
36	75.527	58.358	69.027	62.284	241.868	137.577	136.480	156.927
37	76.830	60.857	71.100	64.346	235.438	138.700	138.712	156.577
38	78.191	63.420	73.198	66.485	229.344	139.781	141.008	156.206
39	79.613	66.051	75.322	68.707	223.561	140.822	143.370	155.815
40	81.096	68.750	77.469	71.014	218.064	141.825	145.802	155.403
41	82.645	71.520	79.640	73.413	212.832	142.791	148.308	154.968
42	84.262	74.363	81.833	75.907	207.846	143.721	150.892	154.512
43	85.949	77.281	84.046	78.502	203.088	144.617	153.560	154.033
44	87.709	80.276	86.279	81.203	198.543	145.479	156.314	153.531
45	89.546	83.351	88.530	84.016	194.196	146.308	159.162	153.005
46	91.462	86.507	90.797	86.947	190.033	147.106	162.108	152.455
47	93.462	89.748	93.079	90.004	186.043	147.873	165.158	151.880
48	95.549	93.075	95.375	93.193	182.214	148.611	168.319	151.279
49	97.727	96.491	97.682	96.522	178.536	149.320	171.597	150.653
50	100.000	100.000	100.000	100.000	175.000	150.000	175.000	150.000

Table 8. Crossing over value (COV) and their standard errors based on the product method when one character pair is determined by two complementary factor differences and the other character pair by two duplicate factor differences-9 : 7 and 15 : 1 for F_2 and 1 : 3 and 3 : 1 for backcross (BC)

COV	Ratio of products, %				$\sqrt{n}\times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
%	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	40.758	20.649	1.014	1.013	11267.08	158.344	32.594	28.109
2	40.809	21.318	2.057	2.051	5635.149	158.561	46.009	39.506
3	40.895	22.006	3.130	3.115	3758.548	158.763	56.253	48.087
4	41.015	22.715	4.233	4.207	2820.777	158.952	64.852	55.186
5	41.170	23.445	5.367	5.325	2258.535	159.126	72.403	61.325
6	41.360	24.197	6.533	6.473	1884.053	159.287	79.210	66.771
7	41.584	24.971	7.731	7.649	16 6.858	159.433	85.458	71.686
8	41.844	25.769	8.961	8.854	1416.714	159.565	91.265	76.175
9	42.140	26.591	10.226	10.090	1261.266	159.683	96.716	80.313
10	42.473	27.438	11.524	11.357	1137.100	159.786	101.872	84.154
11	42.841	28.310	12.858	12.656	1035.682	159.875	106.781	87.738
12	43.247	29.210	14.228	13.988	951.319	159.949	111.478	91.098
13	43.691	30.138	15.634	15.354	880.071	160.008	115.993	94.260
14	44.173	31.094	17.077	16.753	819.124	160.053	120.351	97.245
15	44.695	32.080	18.559	18.188	766.413	160.082	124.572	100.071
16	45.256	33.097	20.079	19.660	720.389	160.097	128.673	102.751
17	45.858	34.147	21.639	21.168	679.869	160.096	132.669	105.299
18	46.501	35.229	23.239	22.715	643.930	160.080	136.572	107.726
19	47.187	36.347	24.881	24.300	611.845	160.048	140.394	110.040
20	47.917	37.500	26.564	25.926	583.032	160.000	144.145	112.250
21	48.691	38.691	28.290	27.593	557.018	159.936	147.834	114.363
22	49.511	39.921	30.060	29.302	533.420	159.857	151.470	116.385
23	50.379	41.191	31.874	31.054	511.916	159.761	155.060	118.323
24	51.295	42.503	33.733	32.851	492.242	159.648	158.612	120.181
25	52.261	43.860	35.638	34.694	474.175	159.519	162.131	121.963
26	53.279	45.262	37.590	36.583	457.524	159.373	165.624	123.675
27	54.350	46.711	39.589	38.521	442.129	159.210	169.097	125.319
28	55.476	48.211	41.636	40.508	427.851	159.030	172.556	126.900
29	56.660	49.762	43.732	42.546	414.572	158.831	176.006	128.419
30	57.902	51.368	45.878	44.637	402.188	158.615	179.452	129.882
31	59.206	53.030	48.074	46.781	390.609	158.381	182.901	131.289
32	60.573	54.751	50.321	48.980	379.756	158.128	186.356	132.643
33	62.007	56.534	52.620	51.235	369.559	157.857	189.823	133.947
34	63.509	58.382	54.971	53.549	359.957	157.566	193.308	135.203
35	65.083	60.298	57.375	55.923	350.896	157.256	196.815	136.412
36	66.732	62.284	59.833	58.358	342.329	156.927	200.350	137.577
37	68.459	64.346	62.344	60.857	334.210	156.577	203.918	138.700
38	70.267	66.485	64.910	63.420	326.503	156.206	207.525	139.781
39	72.161	68.707	67.530	66.051	319.171	155.815	211.176	140.822
40	74.144	71.014	70.206	68.750	312.185	155.403	214.878	141.825
41	76.220	73.413	72.937	71.520	305.515	154.968	218.636	142.791
42	78.394	75.907	75.723	74.363	299.136	154.512	222.457	143.721
43	80.671	78.502	78.565	77.281	293.025	154.033	226.347	144.617
44	83.057	81.203	81.462	80.276	287.161	153.531	230.314	145.479
45	85.557	84.016	84.415	83.351	281.524	153.005	234.365	146.308
46	88.177	86.947	87.423	86.507	276.096	152.455	238.507	147.106
47	90.924	90.004	90.487	89.748	270.861	151.880	242.750	147.873
48	93.805	93.193	93.604	93.075	265.805	151.279	247.103	148.611
49	96.827	96.522	96.775	96.491	260.914	150.653	251.574	149.320
50	100.00_0	100.000	100.000	100.000	256.174	$1^{50.000}$	$^{6.174}_{25}$	150.000

Table 9. Crossing over value (COV) and their standard errors based on the product method when one character pair is determined by two complementary factor differences and the other character pair by two inhibiting factor differences-9 : 7 and 3 : 13 for F_2 or 1 : 3 and 1 : 3 for backcross (BC)

COV	Ratio of products, %				$\sqrt{n}\times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
%	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	73.342	1.013	37.132	20.649	20769.51	28.109	187.539	158.344
2	73.370	2.051	38.275	21.318	10384.76	39.506	190.458	158.561
3	73.415	3.115	39.429	22.006	6923.191	48.087	193.399	158.763
4	73.479	4.207	40.593	22.715	5192.405	55.186	196.362	158.952
5	73.560	5.325	41.768	23.445	4153.935	61.325	199.350	159.126
6	73.660	6.473	42.953	24.197	3461.624	66.771	202.365	159.287
7	73.779	7.649	44.149	24.971	2967.116	71.686	205.409	159.433
8	73.916	8.854	45.354	25.769	2596.236	76.175	208.486	159.565
9	74.071	10.090	46.568	26.591	2307.773	80.313	211.596	159.683
10	74.246	11.357	47.792	27.438	2077.002	84.154	214.743	159.786
11	74.439	12.656	49.025	28.310	1888.188	87.738	217.929	159.875
12	74.651	13.988	50.266	29.210	1730.842	91.098	221.157	159.949
13	74.882	15.354	51.516	30.138	1597.702	94.260	224.428	160.008
14	75.132	16.753	52.774	31.094	1483.579	97.245	227.746	160.053
15	75.402	18.188	54.040	32.080	1384.670	100.071	231.113	160.082
16	75.691	19.660	55.313	33.097	1298.123	102.751	234.533	160.097
17	76.001	21.168	56.594	34.147	1221.754	105.299	238.007	160.096
18	76.330	22.715	57.881	35.229	1153.867	107.726	241.539	160.080
19	76.680	24.300	59.175	36.347	1093.123	110.040	245.132	160.048
20	77.051	25.926	60.474	37.500	1038.449	112.250	248.790	160.000
21	77.443	27.593	61.780	38.691	988.979	114.363	252.515	159.936
22	77.856	29.302	63.091	39.921	944.001	116.385	256.311	159.857
23	78.290	31.054	64.406	41.191	902.929	118.323	260.181	159.761
24	78.746	32.851	65.726	42.503	865.275	120.181	264.130	159.648
25	79.225	34.694	67.051	43.860	830.628	121.963	268.162	159.519
26	79.726	36.583	68.378	45.262	798.640	123.675	272.280	159.373
27	80.251	38.521	69.709	46.711	769.016	125.319	276.489	159.210
28	80.799	40.508	71.043	48.211	741.502	126.900	280.793	159.030
29	81.371	42.546	72.379	49.762	715.879	128.419	285.197	158.831
30	81.967	44.637	73.717	51.368	691.958	129.882	289.707	158.615
31	82.588	46.781	75.056	53.030	669.573	131.289	294.327	158.381
32	83.235	48.980	76.395	54.751	648.579	132.643	299.064	158.128
33	83.907	51.235	77.735	56.534	628.851	133.947	303.922	157.857
34	84.607	53.549	79.075	58.382	610.275	135.203	308.909	157.566
35	85.333	55.923	80.414	60.298	592.752	136.412	314.030	157.256
36	86.087	58.358	81.751	62.284	576.195	137.577	319.293	156.927
37	86.870	60.857	83.086	64.346	560.523	138.700	324.706	156.577
38	87.682	63.420	84.419	66.485	545.668	139.781	330.276	156.206
39	88.523	66.051	85.749	68.707	531.566	140.822	336.011	155.815
40	89.396	68.750	87.075	71.014	518.159	141.825	341.921	155.403
41	90.299	71.520	88.397	73.413	505.396	142.791	348.014	154.968
42	91.235	74.363	89.714	75.907	493.231	143.721	354.302	154.512
43	92.204	77.281	91.026	78.502	481.621	144.617	360.794	154.033
44	93.208	80.276	92.331	81.203	470.529	145.479	367.503	153.531
45	94.246	83.351	93.630	84.016	459.918	146.308	374.441	153.005
46	95.320	86.507	94.921	86.947	449.758	147.106	381.622	152.455
47	96.432	89.748	96.204	90.004	440.018	147.873	389.058	151.880
48	97.581	93.075	97.479	93.193	430.673	148.611	396.767	151.279
49	98.770	96.491	98.745	96.522	421.697	149.320	404.764	150.653
50	100.000	100.000	100.000	100.000	413.068	150.000	413.068	150.000

Table 10. Crossing over value (COV) and their standard errors based on the product method when one character pair is determined by two complementary factor differences and the other character pair by three complementary factor differences-9 : 7 and 27 : 37 for F_2 or 1 : 3 and 1 : 7 for backcross (BC)

COV	Ratio of products, %				$\sqrt{n}\times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
%	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	64.456	1.261	25.745	27.942	11587.07	39.830	108.335	256.948
2	64.490	2.543	26.807	28.627	5793.598	56.090	109.918	256.970
3	64.547	3.847	27.892	29.329	3862.468	68.406	111.512	256.971
4	64.627	5.174	28.999	30.049	2896.923	78.655	113.121	256.950
5	64.729	6.524	30.130	30.786	2317.612	87.568	114.743	256.907
6	64.855	7.897	31.283	31.541	1931.418	95.522	116.382	256.842
7	65.004	9.293	32.459	32.316	1655.577	102.741	118.037	256.755
8	65.177	10.714	33.658	33.110	1448.705	109.373	119.711	256.646
9	65.372	12.160	34.880	33.925	1287.813	115.520	121.404	256.515
10	65.592	13.630	36.124	34.760	1159.107	121.258	123.119	256.361
11	65.835	15.126	37.390	35.618	1053.807	126.643	124.855	256.186
12	66.103	16.648	38.679	36.497	966.064	131.720	126.615	255.987
13	66.395	18.197	39.990	37.400	891.824	136.524	128.400	255.766
14	66.712	19.773	41.323	38.327	828.194	141.085	130.212	255.523
15	67.054	21.376	42.677	39.279	773.051	145.426	132.051	255.256
16	67.421	23.007	44.053	40.257	724.805	149.567	133.920	254.966
17	67.815	24.667	45.449	41.261	682.237	153.526	135.819	254.652
18	68.234	26.356	46.867	42.293	644.401	157.317	137.752	254.315
19	68.680	28.075	48.305	43.354	610.550	160.952	139.718	253.955
20	69.154	29.825	49.763	44.444	580.086	164.444	141.721	253.570
21	69.655	31.605	51.241	45.566	552.524	167.801	143.762	253.161
22	70.184	33.417	52.739	46.720	527.468	171.033	145.842	252.727
23	70.742	35.261	54.255	47.907	504.592	174.147	147.964	252.269
24	71.330	37.137	55.790	49.129	483.622	177.150	150.131	251.786
25	71.947	39.048	57.343	50.388	464.330	180.048	152.343	251.277
26	72.595	40.992	58.914	51.684	446.522	182.847	154.604	250.743
27	73.275	42.971	60.501	53.019	430.032	185.551	156.916	250.182
28	73.987	44.986	62.105	54.395	414.719	188.167	159.281	249.596
29	74.732	47.037	63.724	55.813	400.461	190.697	161.702	248.982
30	75.511	49.126	65.359	57.276	387.153	193.146	164.182	248.342
31	76.325	51.252	67.008	58.786	374.701	195.517	166.723	247.675
32	77.174	53.416	68.671	60.344	363.026	197.814	169.330	246.979
33	78.060	55.620	70.348	61.952	352.056	200.040	172.004	246.256
34	78.984	57.864	72.036	63.614	341.729	202.198	174.751	245.504
35	79.947	60.149	73.736	65.330	331.990	204.289	177.572	244.722
33	80.949	62.477	75.447	67.105	322.790	206.318	180.473	243.912
67	81.993	64.846	77.168	68.941	314.083	208.285	183.457	243.071
38	83.080	67.260	78.897	70.840	305.832	210.193	186.528	242.199
39	84.210	69.718	80.635	72.806	298.001	212.045	189.692	241.297
40	85.385	72.222	82.380	74.843	290.558	213.842	192.954	240.362
41	86.608	74.773	84.131	76.953	283.474	215.585	196.318	239.396
42	87.878	77.371	85.888	79.141	276.723	217.277	199.790	238.396
43	89.199	80.017	87.648	81.410	270.283	218.919	203.376	237.363
44	90.571	82.714	89.412	83.766	264.130	220.512	207.084	236.296
45	91.997	85.461	91.178	86.213	258.247	222.059	210.919	235.193
46	93.479	88.260	92.945	88.755	252.615	223.560	214.889	234.055
47	95.017	91.113	94.712	91.399	247.217	225.016	219.002	232.880
48	96.616	94.019	96.478	94.150	242.039	226.429	223.267	231.668
49	98.276	96.981	98.241	97.015	237.068	227.799	227.693	230.418
50	100.000	100.000	100.000	100.000	232.289	229.129	232.289	229.129

Table 11. Crossing over value (COV) and their standard errors based on the product method when one character pair is determined by two complementary factor differences and the other character pair by three duplicate factor differences-9 : 7 and 63 : 1 for F_2 or 1 : 3 and 7 : 1 for backcross (BC)

COV	Ratio of products, %				$\sqrt{n}\times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
%	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	42.359	27.942	1.137	1.261	22958.08	256.948	65.290	39.830
2	42.411	28.627	2.300	2.543	11482.44	256.970	92.299	56.090
3	42.497	29.329	3.489	3.847	7658.732	256.971	113.009	68.406
4	42.617	30.049	4.703	5.174	5747.998	256.950	130.461	78.655
5	42.772	30.786	5.945	6.524	4602.448	256.907	145.837	87.568
6	42.962	31.541	7.214	7.897	3839.480	256.842	159.744	95.522
7	43.187	32.316	8.512	9.293	3295.124	256.755	172.544	102.741
8	43.447	33.110	9.838	10.714	2887.390	256.646	184.472	109.373
9	43.743	33.925	11.194	12.160	2570.729	256.515	195.695	115.520
10	44.074	34.760	12.579	13.630	2317.810	256.361	206.334	121.258
11	44.443	35.618	13.995	15.126	2111.240	256.186	216.479	126.643
12	44.848	36.497	15.443	16.648	1939.423	255.987	226.203	131.720
13	45.291	37.400	16.922	18.197	1794.329	255.766	235.564	136.524
14	45.772	38.327	18.434	19.773	1670.223	255.523	244.609	141.085
15	46.291	39.279	19.979	21.376	1562.899	255.256	253.377	145.426
16	46.850	40.257	21.559	23.007	1469.201	254.966	261.903	149.567
17	47.449	41.261	23.172	24.667	1386.714	254.652	270.215	153.526
18	48.089	42.293	24.822	26.356	1313.563	254.315	278.338	157.317
19	48.771	43.354	26.507	28.075	1248.264	253.955	286.295	160.952
20	49.495	44.444	28.229	29.825	1189.630	253.570	294.105	164.444
21	50.263	45.566	29.988	31.605	1136.702	253.161	301.786	167.801
22	51.076	46.720	31.786	33.417	1088.691	252.727	309.356	171.033
23	51.935	47.907	33.622	35.261	1044.950	252.269	316.828	174.147
24	52.841	49.129	35.498	37.137	1004.934	251.786	324.216	177.150
25	53.796	50.388	37.414	39.048	968.191	251.277	331.535	180.048
26	54.800	51.684	39.371	40.992	934.333	250.743	338.796	182.847
27	55.857	53.019	41.370	42.971	903.032	250.182	346.011	185.551
28	56.966	54.395	43.411	44.986	874.007	249.596	353.191	188.167
29	58.130	55.813	45.494	47.037	847.015	248.982	360.347	190.697
30	59.351	57.276	47.622	49.126	821.844	248.342	367.491	193.146
31	60.630	58.786	49.793	51.252	798.311	247.675	374.633	195.517
32	61.970	60.344	52.009	53.416	776.256	246.979	381.782	197.814
33	63.373	61.952	54.271	55.620	755.536	246.256	388.951	200.040
34	64.842	63.614	56.579	57.864	736.026	245.504	396.148	202.198
35	66.378	65.330	58.933	60.149	717.616	244.722	403.385	204.289
36	67.985	67.105	61.333	62.477	700.208	243.912	410.673	206.318
37	69.666	68.941	63.782	64.846	683.712	243.071	418.022	208.285
38	71.424	70.840	66.278	67.260	668.051	242.199	425.445	210.193
39	73.261	72.806	68.821	69.718	653.154	241.297	432.951	212.045
40	75.182	74.843	71.414	72.222	638.956	240.362	440.554	213.842
41	77.191	76.953	74.055	74.773	625.400	239.396	448.266	215.585
42	79.291	79.141	76.744	77.371	612.434	238.396	456.101	217.277
43	81.488	81.410	79.482	80.017	600.010	237.363	464.071	218.919
44	83.785	83.766	82.269	82.714	588.084	236.296	472.192	220.512
45	86.188	86.213	85.105	85.461	576.618	235.193	480.478	222.059
46	88.702	88.755	87.989	88.260	565.574	234.055	488.947	223.560
47	91.334	91.399	90.921	91.113	554.920	232.880	497.614	225.016
48	94.090	94.150	93.900	94.019	544.624	231.668	506.499	226.429
49	96.976	97.015	96.927	96.981	534.660	230.418	515.620	227.799
50	100.000	100.000	100.000	100.000	525.000	229.129	525.000	229.129

Table 12. Crossing over value (COV) and their standard errors based on the product method when both character pairs are determined by two duplicate factor differences-15 : 1 and 15 : 1 for F_2 or 3 : 1 and 3 : 1 for backcross (BC)

COV	Ratio of products, %				$\sqrt{n}\times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
%	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	0.035	1.013	16.330	20.648	399.990	28.109	309.873	158.344
2	0.140	2.051	16.889	21.318	399.959	39.506	311.514	158.561
3	0.315	3.115	17.467	22.006	399.907	48.087	313.144	158.763
4	0.560	4.207	18.065	22.715	399.834	55.186	314.761	158.952
5	0.876	5.325	18.683	23.445	399.741	61.325	316.367	159.126
6	1.262	6.473	19.323	24.197	399.627	66.771	317.962	159.287
7	1.719	7.649	19.984	24.971	399.493	71.686	319.544	159.433
8	2.247	8.854	20.670	25.769	399.338	76.175	321.115	159.565
9	2.847	10.090	21.379	26.591	399.162	80.313	322.673	159.683
10	3.518	11.357	22.114	27.438	398.966	84.154	324.219	159.786
11	4.262	12.656	22.876	28.310	398.749	87.738	325.754	159.875
12	5.078	13.988	23.665	29.210	398.512	91.098	327.276	159.949
13	5.967	15.354	24.483	30.138	398.254	94.260	328.786	160.008
14	6.930	16.753	25.331	31.094	397.976	97.245	330.283	160.053
15	7.968	18.188	26.212	32.080	397.677	100.071	331.768	160.082
16	9.080	19.660	27.125	33.097	397.359	102.751	333.240	160.097
17	10.268	21.168	28.073	34.147	397.019	105.299	334.700	160.096
18	11.533	22.715	29.058	35.229	396.660	107.726	336.146	160.080
19	12.874	24.300	30.081	36.347	396.281	110.040	337.580	160.048
20	14.294	25.926	31.144	37.500	395.881	112.250	339.001	160.000
21	15.793	27.593	32.250	38.691	395.462	114.363	340.409	159.936
22	17.373	29.302	33.399	39.921	395.022	116.385	341.803	159.857
23	19.033	31.054	34.596	41.191	394.563	118.323	343.185	159.761
24	20.775	32.851	35.842	42.503	394.084	120.181	344.552	159.648
25	22.600	34.694	37.139	43.860	393.585	121.963	345.907	159.519
26	24.510	36.583	38.491	45.262	393.067	123.675	347.247	159.373
27	26.506	38.521	39.901	46.711	392.529	125.319	348.574	159.210
28	28.588	40.508	41.372	48.211	391.972	126.900	349.887	159.030
29	30.759	42.546	42.906	49.762	391.395	128.419	351.186	158.831
30	33.020	44.637	44.509	51.368	390.799	129.882	352.471	158.615
31	35.372	46.781	46.183	53.030	390.184	131.289	353.741	158.381
32	37.817	48.980	47.934	54.751	389.550	132.643	354.997	158.128
33	40.357	51.235	49.765	56.534	388.897	133.947	356.239	157.857
34	42.993	53.549	51.681	58.382	388.225	135.203	357.466	157.566
35	45.727	55.923	53.688	60.298	387.534	136.412	358.678	157.256
36	48.561	58.358	55.792	62.284	386.825	137.577	359.875	156.927
37	51.497	60.857	57.998	64.346	386.097	138.700	361.057	156.577
38	54.537	63.420	60.314	66.485	385.351	139.781	362.224	156.206
39	57.683	66.051	62.746	68.707	384.586	140.822	363.376	155.815
40	60.938	68.750	65.302	71.014	383.803	141.825	364.513	155.403
41	64.303	71.520	67.991	73.413	383.002	142.791	365.633	154.968
42	67.781	74.363	70.822	75.907	382.183	143.721	366.739	154.512
43	71.375	77.281	73.805	78.502	381.347	144.617	367.828	154.033
44	75.087	80.276	76.951	81.203	380.492	145.479	368.901	153.531
45	78.920	83.351	80.272	84.016	379.620	146.308	369.959	153.005
46	82.876	86.507	83.780	86.947	378.731	147.106	371.000	152.455
47	86.959	89.748	87.491	90.004	377.824	147.873	372.025	151.880
48	91.172	93.075	91.419	93.193	376.899	148.611	373.033	151.279
49	95.518	96.491	95.583	96.522	375.958	149.320	374.025	150.653
50	100.000	100.000	100.000	100.000	375.000	150.000	375.000	150.000

Table 13. Crossing over value (COV) and their standard errors based on the product method when one character pair is determined by two duplicate factor differences and the other character pair by two inhibiting factor differences-15 : 1 and 3 : 13 for F_2 or 3 : 1 and 1 : 3 for backcross (BC)

COV %	Ratio of products, %				$\sqrt{n} \times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	67.357	20.649	2.004	1.013	33278.62	158.344	56.796	28.109
2	67.386	21.318	4.016	2.051	16637.78	158.561	80.655	39.506
3	67.435	22.006	6.036	3.115	11090.16	158.763	99.205	48.087
4	67.503	22.715	8.062	4.207	8315.845	158.952	115.056	55.186
5	67.591	23.445	10.096	5.325	6650.844	159.126	129.219	61.325
6	67.698	24.197	12.136	6.473	5540.502	159.287	142.212	66.771
7	67.826	24.971	14.181	7.649	4747.105	159.433	154.343	71.686
8	67.974	25.769	16.232	8.854	4151.799	159.565	165.813	76.175
9	68.142	26.591	18.288	10.090	3688.551	159.683	176.762	80.313
10	68.330	27.438	20.349	11.357	3317.742	159.786	187.294	84.154
11	68.539	28.310	22.413	12.656	3014.161	159.875	197.486	87.738
12	68.769	29.210	24.481	13.988	2760.998	159.949	207.401	91.098
13	69.020	30.138	26.552	15.354	2546.618	160.008	217.088	94.260
14	69.293	31.094	28.626	16.753	2362.708	160.053	226.588	97.245
15	69.588	32.080	30.701	18.188	2203.171	160.082	235.936	100.071
16	69.905	33.097	32.778	19.660	2063.438	160.097	245.162	102.751
17	70.245	34.147	34.856	21.168	1940.011	160.096	254.290	105.299
18	70.608	35.229	36.934	22.712	1830.170	160.080	263.345	107.726
19	70.994	36.347	39.012	24.300	1731.770	160.048	272.346	110.040
20	71.405	37.500	41.090	25.926	1643.092	160.000	281.312	112.250
21	71.841	38.691	43.166	27.593	1562.745	159.936	290.261	114.363
22	72.302	39.921	45.240	29.302	1489.592	159.857	299.207	116.385
23	72.789	41.191	47.312	31.054	1422.692	159.761	308.166	118.323
24	73.303	42.503	49.381	32.851	1361.262	159.648	317.152	120.181
25	73.844	43.860	51.446	34.694	1304.644	159.519	326.178	121.963
26	74.414	45.262	53.507	36.583	1252.281	159.373	335.258	123.675
27	75.013	46.711	55.563	38.521	1203.698	159.210	344.404	125.319
28	75.641	48.211	57.614	40.508	1158.488	159.030	353.629	126.900
29	76.301	49.762	59.658	42.546	1116.300	158.831	362.946	128.419
30	76.993	51.368	61.696	44.637	1076.831	158.615	372.366	129.882
31	77.718	53.030	63.726	46.781	1039.814	158.381	381.902	131.289
32	78.477	54.751	65.748	48.980	1005.018	158.128	391.567	132.643
33	79.272	56.534	67.762	51.235	972.240	157.857	401.374	133.947
34	80.104	58.382	69.766	53.549	941.298	157.566	411.335	135.203
35	80.975	60.298	71.760	55.923	912.034	157.256	421.465	136.412
36	81.885	62.284	73.743	58.358	884.305	156.927	431.776	137.577
37	82.837	64.346	75.715	60.857	857.985	156.577	442.284	138.700
38	83.832	66.485	77.675	63.420	832.961	156.206	453.003	139.781
39	84.872	68.707	79.622	66.051	809.129	155.815	463.948	140.822
40	85.960	71.014	81.556	68.750	786.400	155.403	475.136	141.825
41	87.097	73.413	83.476	71.520	764.688	154.968	486.585	142.791
42	88.286	75.907	85.380	74.363	743.921	154.512	498.311	143.721
43	89.529	78.502	87.269	77.281	724.028	154.033	510.334	144.617
44	90.829	81.203	89.142	80.276	704.948	153.531	522.674	145.479
45	92.188	84.016	90.998	83.351	686.624	153.005	535.353	146.308
46	93.611	86.947	92.837	86.507	669.005	152.455	548.392	147.106
47	95.099	90.004	94.657	89.748	652.041	151.880	561.817	147.873
48	96.658	93.193	96.458	93.075	635.691	151.279	575.652	148.611
49	98.290	96.522	98.239	96.491	619.913	150.653	589.927	149.320
50	100.000	100.000	100.000	100.000	604.669	150.000	604.669	150.000

Table 14. Crossing over value (COV) and their standard errors based on the product method when one character pair is determined by two duplicate factor differences and the other character pair by three complementary factor differences-15 : 1 and 27 : 37 for F_2 or 3 : 1 and 1 : 7 for backcross (BC)

COV	Ratio of products, %				$\sqrt{n} \times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
%	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	54.623	27.942	1.388	1.261	17070.23	256.948	37.728	39.830
2	54.663	28.627	2.801	2.543	8535.458	256.970	53.386	56.090
3	55.730	29.329	4.241	3.847	5690.686	256.971	65.430	68.406
4	54.824	30.049	5.706	5.174	4268.412	256.950	75.615	78.655
5	54.944	30.786	7.198	6.524	3415.136	256.907	84.622	87.568
6	55.092	31.541	8.716	7.897	2846.356	256.842	92.802	95.522
7	55.266	32.316	10.260	9.293	2440.144	256.755	100.363	102.741
8	55.469	33.110	11.831	10.714	2135.535	256.646	107.442	109.373
9	55.699	33.925	13.429	12.160	1898.659	256.515	114.135	115.520
10	55.957	34.760	15.053	13.630	1709.194	256.361	120.512	121.258
11	56.244	35.618	16.705	15.126	1554.207	256.186	126.626	126.643
12	56.560	36.497	18.383	16.648	1425.078	255.987	132.519	131.720
13	56.904	37.400	20.088	18.197	1315.836	255.766	138.225	136.524
14	57.279	38.327	21.821	19.773	1222.217	255.523	143.773	141.085
15	57.684	39.279	23.580	21.376	1141.096	255.256	149.184	145.426
16	58.119	40.257	25.366	23.007	1070.126	254.966	154.480	149.567
17	58.586	41.261	27.179	24.667	1007.513	254.652	159.677	153.526
18	59.085	42.293	29.019	26.356	951.863	254.315	164.791	157.317
19	59.617	43.354	30.886	28.075	902.074	253.955	169.835	160.952
20	60.182	44.444	32.780	29.825	857.265	253.570	174.821	164.444
21	60.782	45.566	34.700	31.605	816.721	253.161	179.760	167.801
22	61.417	46.720	36.646	33.417	779.859	252.727	184.663	171.033
23	62.088	47.907	38.619	35.261	746.197	252.269	189.539	174.147
24	62.796	49.129	40.617	37.137	715.331	251.786	194.396	177.150
25	63.543	50.388	42.641	39.048	686.925	251.277	199.244	180.048
26	64.328	51.684	44.691	40.992	660.692	250.743	204.090	182.847
27	65.155	53.019	46.765	42.971	636.388	250.182	208.942	185.551
28	66.024	54.395	48.864	44.986	613.805	249.596	213.807	188.167
29	66.936	55.813	50.988	47.037	592.762	248.982	218.693	190.697
30	67.893	57.276	53.135	49.126	573.102	248.342	223.607	193.146
31	68.896	58.786	55.306	51.252	554.690	247.675	228.556	195.517
32	69.948	60.344	57.500	53.416	537.407	246.979	233.548	197.814
33	71.050	61.952	59.715	55.620	521.146	246.256	238.590	200.040
34	72.204	63.614	61.953	57.864	505.817	245.504	243.688	202.198
35	73.412	65.330	64.211	60.149	491.336	244.722	248.851	204.289
36	74.676	67.105	66.490	62.477	477.630	243.912	254.086	206.318
37	75.999	68.941	68.789	64.846	464.635	243.071	259.402	208.285
38	77.383	70.840	71.106	67.260	452.292	242.199	264.805	210.193
39	78.831	72.806	73.440	69.718	440.548	241.297	270.305	212.045
40	80.346	74.843	75.792	72.222	429.356	240.362	275.911	213.842
41	81.932	76.953	78.160	74.773	418.673	239.396	281.630	215.585
42	83.590	79.141	80.543	77.371	408.460	238.396	287.474	217.277
43	85.326	81.410	82.939	80.017	398.683	237.363	293.453	218.919
44	87.143	83.766	85.349	82.714	389.308	236.296	299.575	220.512
45	89.044	86.213	87.769	85.461	380.307	235.193	305.854	222.059
46	91.036	88.755	90.200	88.260	371.653	234.055	312.301	223.560
47	93.122	91.399	92.640	91.113	363.321	232.880	318.929	225.016
48	95.307	94.150	95.088	94.019	355.288	231.668	325.751	226.429
49	97.598	97.015	97.542	96.981	347.533	230.418	332.782	227.799
50	100.000	100.000	100.000	100.000	340.037	229.129	340.037	229.129

Table 15. Crossing over value (COV) and their standard errors based on the product method when one character pair is determined by two duplicate factor differences and the other character pair by three duplicate factor differences-15 : 1 and 63 : 1 for F_2 or 3 : 1 and 7 : 1 for backcross (BC)

COV	Ratio of products, %				$\sqrt{n}\times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
%	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	0.037	1.261	19.529	27.942	799.987	39.830	677.592	256.948
2	0.148	2.543	20.087	28.627	799.949	56.090	780.051	256.970
3	0.332	3.847	20.664	29.329	799.886	68.406	682.484	256.971
4	0.590	5.174	21.259	30.049	799.797	78.655	684.891	256.950
5	0.923	6.524	21.873	30.786	799.683	87.568	687.271	256.907
6	1.329	7.897	22.507	31.541	799.544	95.522	688.626	256.842
7	1.810	9.293	23.162	32.316	799.379	102.741	691.954	256.755
8	2.363	10.714	23.839	33.110	799.189	109.373	694.257	256.646
9	2.995	12.160	24.538	33.952	798.974	115.520	696.535	256.515
10	3.699	13.630	25.262	34.760	798.733	121.258	698.786	256.361
11	4.479	15.126	26.010	35.618	798.468	126.643	701.013	256.186
12	5.334	16.648	26.785	36.497	798.176	131.720	703.214	255.987
13	6.265	18.197	27.586	37.400	797.860	136.524	703.399	255.766
14	7.273	19.773	28.416	38.327	797.518	141.085	707.540	255.523
15	8.356	21.376	29.276	39.279	797.151	145.426	709.666	255.256
16	9.517	23.007	30.168	40.257	796.759	149.567	711.766	254.966
17	10.755	24.667	31.092	41.261	796.341	153.526	713.841	254.652
18	12.071	26.356	32.050	42.293	795.899	157.317	715.892	254.315
19	13.466	28.075	33.045	43.354	795.431	160.952	717.918	253.957
20	14.939	29.825	34.077	44.444	794.938	164.444	719.919	253.570
21	16.492	31.605	35.149	45.566	794.419	167.801	721.895	253.161
22	18.125	33.417	36.263	46.720	793.876	171.033	723.846	252.727
23	19.838	35.261	37.422	47.907	793.308	174.147	725.773	252.269
24	21.633	37.137	38.626	49.129	792.714	177.150	727.675	251.786
25	23.511	39.048	39.880	50.388	792.095	180.048	729.552	251.277
26	25.471	40.992	41.185	51.684	791.451	182.847	731.405	250.743
27	27.515	42.971	42.544	53.019	790.782	185.551	733.233	250.182
28	29.643	44.986	43.961	54.395	790.088	188.167	735.037	249.596
29	31.857	47.037	45.438	55.813	789.369	190.697	736.816	248.982
30	34.156	49.126	46.980	57.276	788.625	193.146	738.570	248.342
31	36.543	51.252	48.589	58.786	787.856	195.517	740.300	247.675
32	39.019	53.416	50.270	60.344	787.062	197.814	742.006	246.979
33	41.583	55.620	52.028	61.952	786.243	200.040	743.687	246.256
34	44.237	57.864	53.866	63.614	785.399	202.198	745.344	245.504
35	46.983	60.149	55.791	65.330	784.530	204.289	746.976	244.722
36	49.821	62.477	57.806	67.105	783.636	206.318	748.584	243.912
37	52.753	64.846	59.919	68.941	782.718	208.285	750.167	243.071
38	55.779	67.260	62.135	70.840	781.774	210.193	751.726	242.199
39	58.901	69.718	64.461	72.806	780.806	212.045	753.260	241.297
40	62.121	72.222	66.905	74.843	779.813	213.842	754.770	240.362
41	65.440	74.773	69.475	76.953	778.795	215.585	756.255	239.396
42	68.858	77.371	72.179	79.141	777.752	217.277	757.716	238.396
43	72.379	80.017	75.027	81.410	776.685	218.919	759.153	237.363
44	76.002	82.714	78.030	83.766	775.592	220.512	760.565	236.296
45	79.730	85.461	81.198	86.213	774.476	222.059	761.952	235.193
46	83.565	88.260	84.544	88.755	773.334	223.560	763.315	234.055
47	87.507	91.113	88.082	91.399	772.168	225.016	764.653	232.880
48	91.559	94.019	91.826	94.150	770.977	226.429	765.967	231.668
49	95.723	96.981	95.792	97.015	769.761	227.799	767.257	230.418
50	100.000	100.000	100.000	100.000	768.521	229.129	768.521	229.129

Table 16. Crossing over value (COV) and their standard errors based on the product method when both character pairs are determined by two inhibiting factor differences-3 : 13 and 3 : 13 for F_2 or 1 : 3 and 1 : 3 for backcross (BC)

COV	Ratio of products, %				$\sqrt{n}\times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
%	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	84.006	1.013	63.519	20.649	47016.98	28.109	530.276	158.344
2	84.024	2.051	64.251	21.318	23509.61	39.506	534.877	158.561
3	84.055	3.115	64.986	22.006	15674.32	48.087	539.570	158.763
4	84.097	3.207	65.724	22.715	11757.05	55.186	544.358	158.952
5	84.152	5.325	66.464	23.445	9406.988	61.325	549.245	159.126
6	84.219	6.473	67.208	24.197	7840.527	66.771	554.234	159.287
7	84.298	7.649	67.954	24.971	6721.839	71.686	559.328	159.433
8	84.390	8.854	68.703	25.769	5883.008	76.175	564.532	159.565
9	84.493	10.090	69.454	26.591	5230.749	80.313	569.849	159.683
10	84.609	11.357	70.207	27.438	4709.089	84.154	575.283	159.786
11	84.737	12.656	70.962	28.310	4282.409	87.738	580.839	159.875
12	84.878	13.988	71.719	29.210	3926.965	91.098	586.520	159.949
13	85.031	15.354	72.478	30.138	3626.317	94.260	592.332	160.008
14	85.196	16.753	73.239	31.094	3368.722	97.245	598.279	160.053
15	85.374	18.188	74.001	32.080	3145.570	100.071	604.366	160.082
16	85.565	19.660	74.764	33.097	2950.401	102.751	610.599	160.097
17	85.767	21.168	75.529	34.147	2778.277	105.299	616.984	160.096
18	85.983	22.715	76.294	35.229	2625.357	107.726	623.525	160.080
19	86.211	24.300	77.060	36.347	2488.608	110.040	630.229	160.048
20	86.452	25.926	77.827	37.500	2365.603	112.250	637.103	160.000
21	86.705	27.593	78.594	38.691	2254.380	114.363	644.153	159.936
22	86.972	29.302	79.361	39.921	2153.330	116.385	651.386	159.857
23	87.251	31.054	80.129	41.191	2061.127	118.323	658 811	159.761
24	87.543	32.851	80.896	42.503	1976.663	120.181	666.434	159.648
25	87.849	34.694	81.663	43.860	1899.010	121.963	674.264	159.519
26	88.167	36.583	82.429	45.262	1827.382	123.675	682.309	159.373
27	88.499	38.521	83.194	46.711	1761.108	125.319	690.580	159.210
28	88.843	40.508	83.958	48.211	1699.615	126.900	699.085	159.030
29	89.202	42.546	84.721	49.762	1642.407	128.419	707.835	158.831
30	89.573	44.637	85.482	51.368	1589.055	129.882	716.840	158.615
31	89.958	46.781	86.242	53.030	1539.186	131.289	726.113	158.381
32	90.357	48.980	86.999	54.751	1492.472	132.643	735.665	158.128
33	90.770	51.235	87.754	56.534	1448.627	133.947	745.509	157.857
34	91.196	53.549	88.507	58.382	1407.396	135.203	755.659	157.566
35	91.636	55.923	89.257	60.298	1368.556	136.412	766.130	157.256
36	92.091	58.358	90.005	62.284	1331.906	137.577	776.935	156.927
37	92.559	60.857	90.748	64.346	1297.268	138.700	788.093	156.577
38	93.042	63.420	91.489	66.485	1264.484	139.781	799.621	156.206
39	93.539	66.051	92.225	68.707	1233.409	140.822	811.536	155.815
40	94.051	68.750	92.958	71.014	1203.916	141.825	823.859	155.403
41	94.578	71.520	93.686	73.413	1175.888	142.791	836.611	154.968
42	95.119	74.363	94.410	75.907	1149.220	143.721	849.814	154.512
43	95.675	77.281	95.129	78.502	1123.817	144.617	863.493	154.033
44	96.246	80.276	95.842	81.203	1099.592	145.479	877.674	153.531
45	96.833	83.351	96.550	84.016	1076.466	146.308	892.384	153.005
46	97.435	86.507	97.253	86.947	1054.367	147.106	907.653	152.455
47	98.053	89.748	97.949	90.004	1033.229	147.873	923.513	151.880
48	98.686	93.075	98.640	93.193	1012.991	148.611	939.999	151.279
49	99.335	96.491	99.323	96.522	993.599	149.320	957.148	150.653
50	100.000	100.000	100.000	100.000	975.000	150.000	975.000	150.000

Table 17. Crossing over value (COV) and their standard errors based on the product method when one character pair is determined by two inhibiting factor differences and the other character pair by three complementary factor differences-3 : 13 and 27 : 37 for F_2 or 1 : 3 and 1 : 7 for backcross (BC)

COV %	Ratio of products, %				$\sqrt{n}\times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	78.674	1.261	50.546	27.942	26989.01	39.830	277.479	256.948
2	78.697	2.543	51.492	28.627	13494.82	56.090	280.524	256.970
3	78.736	3.847	52.445	29.329	8996.911	68.406	283.618	256.971
4	78.790	5.174	53.404	30.049	6748.059	78.655	286.761	256.950
5	78.859	6.524	54.369	30.786	5398.834	87.568	289.955	256.907
6	78.944	7.897	55.341	31.541	4499.421	95.522	293.204	256.842
7	79.044	9.293	56.317	32.316	3857.043	102.741	296.508	256.755
8	79.159	10.714	57.300	33.110	3375.313	109.373	299.871	256.646
9	79.291	12.160	58.287	33.925	3000.680	115.520	303.294	256.515
10	79.438	13.630	59.280	34.760	2701.015	121.258	306.780	256.361
11	79.601	15.126	60.278	35.618	2455.871	126.643	310.332	256.186
12	79.779	16.648	61.281	36.497	2251.619	131.720	313.951	255.987
13	79.974	18.197	62.288	37.400	2078.820	136.524	317.642	255.766
14	80.184	19.773	63.299	38.327	1930.735	141.085	321.406	255.523
15	80.411	21.376	64.314	39.279	1802.421	145.426	325.247	255.256
16	80.653	23.007	65.333	40.257	1690.170	149.567	329.168	254.966
17	80.913	24.667	66.356	41.261	1591.146	153.526	333.172	254.652
18	81.188	26.356	67.382	42.293	1503.146	157.317	337.263	254.315
19	81.481	28.075	68.411	43.354	1424.428	160.952	341.444	253.955
20	81.790	29.825	69.442	44.444	1353.599	164.444	345.719	253.570
21	82.115	31.605	70.476	45.566	1289.532	167.801	350.091	253.161
22	82.458	33.417	71.513	46.720	1231.305	171.033	354.566	252.727
23	82.819	35.261	72.551	47.907	1178.155	174.147	359.147	252.269
24	83.196	37.137	73.590	49.129	1129.447	177.150	363.839	251.786
25	83.592	39.048	74.631	50.388	1084.648	180.048	368.646	251.277
26	84.005	40.992	75.673	51.684	1043.306	182.847	373.575	250.743
27	84.436	42.971	76.715	53.019	1005.037	185.551	378.630	250.182
28	84.886	44.986	77.758	54.395	969.512	188.167	383.816	249.596
29	85.354	47.037	78.800	55.813	936.445	190.697	389.141	248.982
30	85.840	49.126	79.843	57.276	905.591	193.146	394.609	248.342
31	86.346	51.252	80.884	58.786	876.736	195.517	400.228	247.675
32	86.871	53.416	81.924	60.344	849.690	197.814	406.005	246.979
33	87.416	55.620	82.963	61.952	824.290	200.040	411.947	246.256
34	87.980	57.864	83.999	63.614	800.391	202.198	418.062	245.504
35	88.565	60.149	85.034	65.330	777.862	204.289	424.358	244.722
36	89.170	62.477	86.066	67.105	756.589	206.318	430.845	243.912
37	89.796	64.846	87.094	68.941	736.470	208.285	437.531	243.071
38	90.443	67.260	88.120	70.840	717.414	210.193	444.428	242.199
39	91.111	69.718	89.141	72.806	699.338	212.045	451.545	241.297
40	91.802	72.222	90.158	74.843	682.169	213.842	458.893	240.362
41	92.514	74.773	91.171	76.953	665.839	215.585	466.486	239.396
42	93.249	77.371	92.178	79.141	650.289	217.277	474.336	238.396
43	94.008	80.017	93.180	81.410	635.464	218.919	482.457	237.363
44	94.790	82.714	94.175	83.766	621.313	220.512	490.864	236.296
45	95.595	85.461	95.165	86.213	607.792	222.059	499.572	235.193
46	96.425	88.260	96.147	88.755	594.858	223.560	508,600	234.055
47	97.280	91.113	97.123	91.399	582.475	225.016	517.965	232.880
48	98.161	94.019	98.090	94.150	570.608	226.429	527.688	231.668
49	99.067	96.981	99.049	97.015	559.223	227.799	537.789	230.418
50	100.000	100.000	100.000	100.000	548.293	229.129	548.293	229.129

Table 18. Crossing over value (COV) and their standard errors based on the product method when one character pair is determined by two inhibiting factor differences and the other character pair by three duplicate factor differences-3 : 13 and 63 : 1 for F_2 or 1 : 3 and 7 : 1 for backcross (BC)

COV %	Ratio of products, %				$\sqrt{n} \times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	68.790	27.942	2.126	1.261	68610.10	256.948	113.681	39.830
2	68.818	28.627	4.254	2.543	34301.69	256.970	161.559	56.090
3	68.865	29.329	6.383	3.847	22864.05	256.971	198.863	68.406
4	68.930	30.049	8.514	5.174	17144.11	256.950	230.807	78.655
5	69.015	30.786	10.645	6.524	13711.24	256.907	259.405	87.568
6	69.118	31.541	12.776	7.897	11421.90	256.842	285.689	95.522
7	69.241	32.316	14.908	9.293	9786.018	256.755	310.273	102.741
8	69.383	33.110	17.039	10.714	8558.530	256.646	333.556	109.373
9	69.544	33.925	19.169	12.160	7603.306	256.515	355.818	115.520
10	69.725	34.760	21.298	13.630	6838.663	256.361	377.263	121.258
11	69.926	35.618	23.426	15.126	6212.622	256.186	398.047	126.643
12	70.147	36.497	25.551	16.648	5690.528	255.987	418.293	131.720
13	70.388	37.400	27.674	18.197	5248.392	255.766	438.098	136.524
14	70.650	38.327	29.793	19.773	4869.075	255.523	457.544	141.085
15	70.933	39.279	31.910	21.376	4540.010	255.256	476.700	145.426
16	71.238	40.257	34.023	23.007	4251.773	254.966	495.625	149.567
17	71.564	41.261	36.131	24.667	3997.153	254.652	515.369	153.526
18	71.912	42.293	38.234	26.356	3770.546	254.315	532.979	157.317
19	72.283	43.354	40.333	28.075	3567.524	253.955	551.494	160.952
20	72.678	44.444	42.425	29.825	3384.546	253.570	569.952	164.444
21	73.096	45.566	44.512	31.605	3218.745	253.161	588.387	167.801
22	73.538	46.720	46.592	33.417	3067.775	252.727	606.829	171.033
23	74.005	47.907	48.664	35.261	2929.698	252.269	625.310	174.147
24	74.498	49.129	50.729	37.137	2802.898	251.786	643.856	177.150
25	75.017	50.388	52.786	39.048	2686.019	251.277	662.496	180.048
26	75.563	51.684	54.834	40.992	2577.911	250.743	681.255	182.847
27	76.137	53.019	56.873	42.971	2477.597	250.182	700.160	185.551
28	76.739	54.395	58.902	44.986	2384.237	249.596	719.235	188.167
29	77.371	55.813	60.922	47.037	2297.109	248.982	738.505	190.697
30	78.034	57.276	62.930	49.126	2215.584	248.342	757.996	193.146
31	78.728	58.786	64.927	51.252	2139.117	247.675	777.733	195.517
32	79.455	60.344	66.912	53.416	2067.229	246.979	797.741	197.814
33	80.216	61.952	68.885	55.620	1999.499	246.256	818.047	200.040
34	81.012	63.614	70.845	57.864	1935.557	245.504	838.676	202.198
35	81.844	65.330	72.792	60.149	1875.074	244.722	859.657	204.289
36	82.715	67.105	74.724	62.477	1817.757	243.912	881.017	206.318
37	83.625	68.941	76.642	64.846	1763.344	243.071	902.785	208.285
38	84.576	70.840	78.545	67.260	1711.602	242.199	924.993	210.193
39	85.571	72.806	80.433	69.718	1662.321	241.297	947.672	212.045
40	86.610	74.843	82.304	72.222	1615.312	240.362	970.854	213.842
41	87.696	76.953	84.158	74.773	1570.403	239.396	994.576	215.585
42	88.831	79.141	85.995	77.371	1527.439	238.396	1018.873	217.277
43	90.017	81.410	87.814	80.017	1486.281	237.363	1043.785	218.919
44	91.258	83.766	89.615	82.714	1446.799	236.296	1069.353	220.512
45	92.555	86.213	91.397	85.461	1408.876	235.193	1095.621	222.059
46	93.911	88.755	93.159	88.260	1372.406	234.055	1122.635	223.560
47	95.331	91.399	94.901	91.113	1337.291	232.880	1150.446	225.016
48	96.816	94.150	96.622	94.019	1303.440	231.668	1179.105	226.429
49	98.371	97.015	98.322	96.981	1270.769	230.418	1208.670	227.799
50	100.000	100.000	100.000	100.000	1239.203	229.129	1239.203	229.129

Table 19. Crossing over value (COV) and their standard errors based on the product method when both character pairs are determined by three complementary factor differences-27 : 37 and 27 : 37 for F_2 or 1 : 7 and 1 : 7 for backcross (BC)

COV %	Ratio of products, %				$\sqrt{n}\times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	71.565	1.508	37.499	36.621	15291.95	56.416	152.463	432.014
2	71.594	3.033	38.536	37.256	7646.092	79.568	154.242	430.994
3	71.643	4.574	39.589	37.905	5097.520	97.188	156.048	429.953
4	71.710	6.132	40.655	38.568	3823.272	111.920	157.882	428.891
5	71.798	7.707	41.736	39.247	3058.752	124.793	159.746	427.808
6	71.905	9.299	42.832	38.941	2549.097	136.336	161.639	426.702
7	72.031	10.909	43.941	40.651	2185.079	146.864	163.564	425.574
8	72.177	12.536	45.064	41.378	1912.083	156.582	165.522	424.424
9	72.343	14.182	46.201	42.121	1699.769	165.634	167.513	423.251
10	72.529	15.845	47.351	42.883	1529.932	174.125	169.541	422.055
11	72.735	17.526	48.515	43.662	1390.987	182.133	171.605	420.836
12	72.961	19.226	49.691	44.461	1275.210	189.722	173.707	419.593
13	73.207	20.945	50.881	45.279	1177.256	196.940	175.850	418.325
14	73.475	22.682	52.082	46.117	1093.304	203.827	178.034	417.034
15	73.763	24.439	53.296	46.976	1020.555	210.416	180.261	415.717
16	74.072	26.215	54.522	47.857	956.906	216.736	182.533	414.375
17	74.402	28.011	55.759	48.760	900.753	222.809	184.853	413.007
18	74.754	29.826	57.007	49.687	850.845	228.656	187.221	411.614
19	75.127	31.662	58.266	50.637	806.197	234.294	189.640	410.193
20	75.523	33.518	59.535	51.613	766.019	239.739	192.112	408.746
21	75.941	35.394	60.815	52.615	729.672	245.005	194.639	407.272
22	76.381	37.292	62.104	53.643	696.633	250.102	197.224	405.770
23	76.845	39.210	63.403	54.700	666.472	255.041	199.869	404.240
24	77.333	41.150	64.710	55.786	638.828	259.832	202.577	402.681
25	77.844	43.111	66.025	56.902	613.398	264.484	205.351	401.092
26	78.379	45.094	67.349	58.050	589.927	269.004	208.192	399.474
27	78.939	47.099	68.680	59.231	568.197	273.399	211.105	397.826
28	79.524	49.127	70.018	60.446	548.022	277.676	214.093	396.147
29	80.134	51.177	71.362	61.697	529.240	281.839	217.158	394.436
30	80.771	53.251	72.712	62.984	511.712	285.896	220.305	392.693
31	81.435	55.347	74.067	64.311	495.315	289.849	223.537	390.918
32	82.125	57.467	75.427	65.678	479.945	293.705	226.859	389.110
33	82.843	59.611	76.792	67.088	465.507	297.467	230.274	387.268
34	83.590	61.778	78.160	68.542	451.919	301.139	233.786	385.391
35	84.365	63.971	79.531	70.042	439.107	304.725	237.402	383.479
36	85.170	66.188	80.904	71.591	427.008	308.227	241.125	381.531
37	86.006	68.430	82.279	73.191	415.562	311.650	244.962	379.546
38	86.872	70.697	83.655	74.843	404.718	314.996	248.917	377.523
39	87.771	72.990	85.032	76.552	394.430	318.267	252.997	375.463
40	88.701	75.309	86.408	78.320	384.655	321.467	257.208	373.363
41	89.666	77.654	87.784	80.149	375.356	324.598	261.557	371.223
42	90.664	80.026	89.157	82.043	366.499	327.662	266.053	369.043
43	91.698	82.424	90.529	84.006	358.052	330.661	270.701	366.820
44	92.767	84.850	91.897	86.040	349.987	333.597	275.512	364.554
45	93.874	87.304	93.262	88.150	342.279	336.473	280.493	362.245
46	95.019	89.786	94.622	90.341	334.905	339.290	285.655	359.891
47	96.202	92.296	95.976	92.616	327.842	342.049	291.009	357.490
48	97.426	94.835	97.325	94.981	321.071	344.753	296.565	355.042
49	98.692	97.403	98.666	97.440	314.573	347.403	302.335	352.546
50	100.000	100.000	100.000	100.000	308.333	350.000	308.333	350.000

Table 20. Crossing over value (COV) and their standard errors based on the product method when one character pair is determined by three complementary factor differences and the other character pair by three duplicate factor differences-27 : 37 and 63 : 1 for F_2 or 1 : 7 and 1 : 7 for backcross (BC)

COV %	Ratio of products, %				$\sqrt{n}\times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	56.252	36.621	1.510	1.508	34997.62	432.014	75.542	56.416
2	56.292	37.256	3.042	3.033	17499.55	430.994	107.009	79.568
3	56.357	37.905	4.595	4.574	11667.18	429.953	131.289	97.188
4	56.449	38.568	6.169	6.132	8751.239	428.891	151.879	111.920
5	56.567	39.247	7.764	7.707	7001.860	427.808	170.138	124.793
6	56.711	39.941	9.381	9.299	5835.761	426.702	186.760	136.336
7	56.883	40.651	11.020	10.909	5002.959	425.574	202.160	146.864
8	57.081	41.378	12.680	12.536	4378.465	424.424	216.609	156.582
9	57.306	42.121	14.362	14.182	3892.837	423.251	230.296	165.634
10	57.559	42.883	16.066	15.845	3504.411	422.055	243.360	174.125
11	57.839	43.662	17.792	17.526	3186.673	420.836	255.906	182.133
12	58.148	44.461	19.539	19.226	2921.947	419.593	268.017	189.722
13	58.485	45.279	21.309	20.945	2697.993	418.325	279.759	196.940
14	58.851	46.117	23.100	22.682	2506.071	417.034	291.188	203.827
15	59.247	46.976	24.913	24.439	2339.769	415.717	302.350	210.416
16	59.673	47.857	26.748	26.215	2194.278	414.375	313.283	216.736
17	60.129	48.760	28.604	28.011	2065.921	413.007	324.021	222.809
18	60.616	49.687	30.483	29.826	1951.839	411.614	334.595	228.656
19	61.135	50.637	32.382	31.662	1849.771	410.193	345.031	234.294
20	61.686	51.613	34.304	33.518	1757.910	408.746	355.353	239.739
21	62.270	52.615	36.246	35.394	1674.795	407.272	365.582	245.005
22	62.889	53.643	38.209	37.292	1599.226	405.770	375.740	250.102
23	63.542	54.700	40.194	39.210	1530.216	404.240	385.844	255.041
24	64.232	55.786	42.199	41.150	1466.939	402.681	395.912	259.832
25	64.958	56.902	44.224	43.111	1408.702	401.092	405.960	264.484
26	65.722	58.050	46.269	45.094	1354.919	399.474	416.006	269.004
27	66.525	59.231	48.335	47.099	1305.090	397.826	426.063	273.399
28	67.368	60.446	50.419	49.127	1258.786	396.147	436.148	277.676
29	68.253	61.697	52.523	51.177	1215.638	394.436	446.274	281.839
30	69.181	62.984	54.645	53.251	1175.325	392.693	456.453	285.896
31	70.153	64.311	56.786	55.347	1137.567	390.918	466.712	289.849
32	71.171	65.678	58.944	57.467	1102.121	389.110	477.051	293.705
33	72.237	67.088	61.119	59.611	1068.771	387.268	487.491	297.467
34	73.352	68.542	63.311	61.778	1037.327	385.391	498.047	301.139
35	74.518	70.042	65.519	63.971	1007.621	383.479	508.732	304.725
36	75.738	71.591	67.742	66.188	979.502	381.531	519.563	308.227
37	77.014	73.191	69.980	68.430	952.838	379.546	530.556	311.650
38	78.348	74.843	72.232	70.697	927.507	377.523	541.727	314.996
39	79.742	76.552	74.497	72.990	903.403	375.463	553.094	318.267
40	81.199	78.320	76.774	75.309	880.428	373.363	564.674	321.467
41	82.722	80.149	79.062	77.654	858.494	371.223	576.486	324.598
42	84.315	82.043	81.361	80.026	837.522	369.043	588.549	327.662
43	85.980	84.006	83.669	82.424	817.439	366.820	600.885	330.661
44	87.721	86.040	85.986	84.850	798.180	364.554	613.515	333.597
45	89.542	88.150	88.310	87.304	779.684	362.245	626.462	336.473
46	91.446	90.341	90.641	89.786	761.896	359.891	639.751	339.290
47	93.440	92.616	92.976	92.296	744.765	357.490	653.407	342.049
48	95.526	94.981	95.315	94.835	728.245	355.042	667.458	344.753
49	97.711	97.440	97.657	97.403	712.293	352.546	681.935	347.403
50	100.000	100.000	100.000	100.000	696.868	350.000	696.868	350.000

Table 21. Crossing over value (COV) and their standard errors based on the product method when both character pairs are determined by three duplicate factor differences-63 : 1 and 63 : 1 for F_2 or 7 : 1 and 7 : 1 for backcross (BC)

COV %	Ratio of products, %				$\sqrt{n}\times$ (Standard error), %			
	ad/bc, Repulsion		bc/ad, Coupling		ad/bc, Repulsion		bc/ad, Coupling	
	F_2	BC	F_2	BC	F_2	BC	F_2	BC
1	0.039	1.508	23.181	36.621	1599.990	56.416	1504.159	432.014
2	0.155	3.033	23.719	37.256	1599.960	79.568	1506.031	430.994
3	0.349	4.574	24.273	37.905	1599.909	97.188	1507.886	429.953
4	0.620	6.132	24.846	38.568	1599.839	111.920	1509.723	428.891
5	0.969	7.707	25.436	39.247	1599.748	124.793	1511.544	427.808
6	1.396	9.299	26.046	39.941	1599.637	136.336	1513.348	426.702
7	1.900	10.909	26.676	40.651	1599.506	146.864	1515.134	425.574
8	2.482	12.536	27.326	41.378	1599.355	156.582	1516.903	424.424
9	3.142	14.182	27.998	42.121	1599.184	165.634	1518.655	423.251
10	3.880	15.845	28.692	42.883	1599.992	174.125	1520.390	422.055
11	4.696	17.526	29.410	43.662	1598.781	182.133	1522.107	420.836
12	5.590	19.226	30.153	44.461	1598.549	189.722	1523.807	419.593
13	6.563	20.945	30.922	45.279	1598.297	196.940	1525.490	418.325
14	7.614	22.682	31.718	46.117	1598.025	203.827	1527.154	417.034
15	8.744	24.439	32.542	46.976	1597.734	210.416	1528.802	415.717
16	9.952	26.215	33.395	47.857	1597.421	216.736	1530.432	414.375
17	11.240	28.011	33.280	48.760	1597.089	222.809	1532.044	413.007
18	12.606	29.826	35.198	49.687	1596.737	228.656	1533.638	411.614
19	14.053	31.662	36.150	50.637	1596.365	234.294	1535.214	410.193
20	15.578	33.518	37.137	51.613	1595.973	239.739	1536.773	408.746
21	17.184	35.394	38.163	52.615	1595.561	245.005	1538.314	407.272
22	18.870	37.292	39.228	53.643	1595.129	250.102	1539.837	405.770
23	20.636	39.210	40.336	54.700	1594.676	255.041	1541.342	404.240
24	22.483	41.150	41.487	55.786	1594.204	259.832	1542.828	402.681
25	24.411	43.111	42.685	56.902	1593.712	264.484	1544.297	401.092
26	26.420	45.094	43.932	58.050	1593.200	269.004	1545.748	399.474
27	28.510	47.099	45.230	59.231	1592.669	273.399	1547.180	397.826
28	30.682	49.127	46.583	60.446	1592.117	277.676	1548.594	396.147
29	32.937	51.177	47.994	61.697	1591.545	281.839	1549.990	394.436
30	35.274	53.251	49.465	62.984	1590.954	285.896	1551.368	392.693
31	37.694	55.347	51.002	64.311	1590.343	289.849	1552.727	390.918
32	40.197	57.467	52.606	65.678	1589.712	293.705	1554.068	389.110
33	42.784	59.611	54.283	67.088	1589.061	297.467	1555.390	387.268
34	45.455	61.778	56.037	68.542	1588.390	301.139	1556.694	385.391
35	48.210	63.971	57.872	70.042	1587.700	304.725	1557.979	383.479
36	51.050	66.188	59.795	71.591	1586.990	308.227	1559.245	381.531
37	53.976	68.430	61.810	73.191	1586.260	311.650	1560.493	379.546
38	56.987	70.697	63.923	74.843	1585.511	314.996	1561.723	377.523
39	60.085	72.990	66.140	76.552	1584.742	318.267	1562.933	375.463
40	63.269	75.309	68.470	78.320	1583.954	321.467	1564.125	373.363
41	66.541	77.654	70.920	80.149	1583.146	324.598	1565.298	371.223
42	69.900	80.026	73.497	82.043	1582.319	327.662	1566.452	369.043
43	73.348	82.424	76.211	84.006	1581.472	330.661	1567.587	366.820
44	76.884	84.850	79.072	86.040	1580.605	333.597	1568.703	364.554
45	80.510	87.304	82.090	88.150	1579.719	336.473	1569.800	362.245
46	84.226	89.786	85.278	90.341	1578.814	339.290	1570.878	359.891
47	88.032	92.296	88.648	92.616	1577.890	342.049	1571.938	357.490
48	91.929	94.835	92.214	94.981	1576.946	344.753	1572.977	355.042
49	95.918	97.403	95.993	97.440	1575.982	347.403	1573.998	352.546
50	100.000	100.000	100.000	100.000	1575.000	350.000	1575.000	350.000